Screening and Prevention of Type 2 Diabetes Mellitus in Women with a History of Gestational Diabetes:

A Systemic Review

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Abstract

Purpose: Review interventions that increase screening for or prevention of type 2 diabetes mellitus in women with gestational diabetes mellitus.

Background: Women with gestational diabetes mellitus are at greater risk for developing type 2 diabetes mellitus. Studies conducted on other high-risk subjects have had success reducing rates of type 2 diabetes mellitus.

Methods: An online search of three electronic databases was conducted. Studies were read and evaluated for design, sample, intervention type, and results.

Results : A limited number of studies have been completed. Short-term success at reducing modifiable risk factor was found using a lifestyle intervention or diet, while educational interventions to improve screening rates had significant successes. Vitamin D had only a small impact, while Metformin showed promise in women with GDM. Breastfeeding was linked to delaying or preventing type 2 diabetes mellitus.

Conclusions: The findings of this review were limited. There is potential to delay type 2 diabetes in women with GDM, however more research in this area is required.

Background

The prevalence of gestational diabetes mellitus (GDM) in the last 10 years has increased with 2 to 10 % of all pregnancies in the United States now affected (Hunt & Schuller, 2007). GDM does not only create risks for women and infants during pregnancy, but also increases these women's lifetime risk of developing type II diabetes mellitus (T2DM) (Bellamy et al., 2009). There has been success delaying the onset or preventing T2DM by decreasing the modifiable risk factors in high-risk subjects (Tuomilehto et al., 2001). T2DM has a complex disease process that include non-modifiable risk factors such as family history and ethnicity, and modifiable risk factor that include weight and diet. Understanding the risk factors for T2DM allow us to identify at risk individuals, such as women with a history of GDM, and develop strategies for prevention. The purpose of this systematic review is to examine the efficacy and feasibility of interventions tested on women with a history of GDM that could delay or prevent the onset of T2DM.

Methods

Literature Search

A search of titles and abstracts was conducted in PubMed, Cinahl, and Cochrane using the keywords "gestational diabetes mellitus", "postpartum", and "intervention". The search was completed February 23rd through the 26th of 2014. There were 61 results from three searches. Studies that did not assess interventions or variables that affected T2DM outcomes in women with a present or past history of GDM were eliminated. Studies were evaluated by examining titles and abstracts. The process used for study selection is outlined in Figure 1. No restrictions were made on publication dates due to the limited results. Only studies written in English were included. Eleven studies were included in this review.

Diagnosis of Gestational Diabetes Mellitus

Diagnosis of GDM varied between studies. All diagnosis criteria were included. Studies used the Oral Glucose Tolerance Test (OGTT) and/or fasting glucose. One study used the American Diabetes Association (ADA) criteria, 1 used Canadian Diabetes Association criteria, 2 used the Carpenter-Coustan criteria, 1 used German Diabetes Association criteria, 1 used the International Association of Diabetes and Pregnancy Study Groups criteria, 1 used National Diabetes Data Group (NDDG) criteria, 3 used the World Health Organization (WHO) criteria, and 1 study did not define specific criteria. Each criterion is outlined in Table 2. GDM was self-reported by participants in the study without criteria.

Article Analysis

Each article was read in its entirety. Study design and sample were evaluated to determine the quality of research. Sample demographics were also evaluated to determine applicability to populations in the United States. Interventions were categorized as behavioral or pharmacologic. Behavioral interventions were then classified into lifestyle or screening interventions. Interventions were then compared by duration and effectiveness. Weaknesses in studies were explored and discussed. Suggestions for future research and care of women with a history of GDM were based on study results and weaknesses. Findings were organized and placed into Table 2.

Results

Study Designs and Samples

Of the 11 studies reviewed, 6 (Cao et al., 2012; Ferrara et al., 2011; Mozaffari-Khosravi et al., 2012; Ratner et al., 2008; Shek et al., 2014; Shyam et al., 2013) were randomized-control trials. Randomized-controlled trials were considered the optimal study design, however with the

limited results from the literature search other study designs were included. Out of the 6 randomized-control trials, 2 trials (Mozaffari-Khosravi et al., 2012; Shyam et al., 2013) had less than 100 participants, and none had more than 450 participants with a history of GDM.

Four studies of the 11 studies (Capula et al., 2013; Fehler et al., 2007; Stasenko et al., 2011; Vesco et al. 2012) were a pre/post-intervention design. Capula et al. (2013) and Stasenko et al. (2011) each implemented their intervention on 245 or more women. Vesco et al. (2012) intervention group contained 179 women, and Fehler et al. (2007) had a smallest sample size of 19 participants. Three studies (Capula et al., 2013; Stasenko et al., 2011; Vesco et al., 2012) compared the intervention groups to statistics from the healthcare systems' previous patient outcomes. Fehler et al. (2007) compared the subjects' baseline behavior to behavior after the intervention.

The final study (Ziegler et al., 2012) examined was an observational study. It investigated the effect of breastfeeding on the T2DM outcomes and body mass index (BMI). The study followed 304 women up to 19 years postpartum or until they developed T2DM.

The majority of the available studies were not the optimal design or had fewer subjects than preferred. Also limited number of studies decreased replication of similar interventions that would add strength to findings.

Demographics

Seven of the studies were not completed within the United States (U.S.). Of these 7, 4 were set in Asia, 2 in Europe, and 1 in Canada. Due to the differences in healthcare, ethnicity, socioeconomic status, and other variables in other countries; interventions may have different outcomes if tested on subjects in the U.S. The remaining 4 studies were completed in the U.S. Two studies (Ferrara et al., 2011; Stasenko et al., 2011) had a majority of Asian American

participants. The ethnic representation in Ratner et al. (2008) was similar to that of the U.S as a whole. Vesco et al. (2012) had a similar distribution of ethnicities, however there was an increased number of Asian American women in their sample. These sample demographics are important when determining effectiveness of interventions in different populations and for research suggestions.

Interventions

Lifestyle Interventions. Four (Cao et al., 2012; Ferrara et al., 2011; Ratner et al., 2008; Shek et al., 2014) of the studies tested what they described as a lifestyle intervention. This included both diet and exercise. Cao et al. (2012) provided one-to-one education that was personalized. The intervention included diabetes education, advise on diet and exercise, and instruction on glucose self- monitoring. It is not stated when the intervention was performed, but it can be inferred that it was before delivery, since infant health outcomes were measured. Follow-up appointments for mothers ranged from 1 to 3 years postpartum.

Ratner et al. (2008) examined women in the Diabetes Prevention Program (DPP) that had a history of GDM. One of the groups received what is called the "Intensive Lifestyle Intervention" (ILS) created for DPP. It included weight loss and physical activity goals, dietary modifications, "lifestyle coaches," core curriculum, supervised exercise sessions, supplemental classes, materials, and strategies for different ethnicities (The Diabetes Prevention Program Research Group, 2002). Women were monitored for 3 years. This intervention was ongoing compared to Cao et al. (2012) short-term intervention. This may have created better adherence, which had a positive affect on outcomes discussed in results.

Both Ferrara et al. (2011) and Shek et al. (2014) provided education on diet and exercise taught by a dietician. Ferrara et al. (2011) adapted the DPP curriculum to create three phase:

prenatal, postpartum, and maintenance. The intervention started soon after diagnosis and ended 12 months postpartum. The intervention incorporated in person and telephone counseling. Participants were given weight and physical activity goals. They were also given information on necessary dietary changes and encouraged to breastfeed. Shek et al. (2014) also used a nurse trained in dietetics to supplement the dietician's initial counseling at follow-up appointments. Women in this study were seen several times over the course of 36 months.

Dietary Interventions. Two studies focused their intervention primarily on diet. Fehler et al. (2007) provided group nutrition education taught by a dietician. It was also mentioned that participants were informed of the benefits of exercise, but no further details provided. Using food records kept by participants to monitor outcomes, the women were seen 4 times during the 6 months postpartum period. The intervention was started prenatally, but gestational weeks varied. Shyam et al. (2013) used one-to-one sessions with a nutritionist to provide participants information on diet. Thirty minutes of physical activity 5 times a week was also encouraged. The intervention group in this study got additional teaching on benefits of low glycemic foods, and how to make substitutions for high glycemic foods. Follow-ups were conducted at 3 months and 6 months. Information was also collected using food records.

Screening Interventions. Three studies looked to increase the rate postpartum screening. Two focused on educating the patient and one on improving the system for scheduling and reminders. Both Capula et al. (2013) and Stasenko et al. (2011) provided their patient participants with written and verbal counseling. Capula et al. (2013) provided counseling at 35-40 weeks. Stasenko et al. (2011) stated that education took place at 37-38 week doctors visit and counseling lasted 5-10 minuets with a nurse, who was a certified diabetes educator. The study performed by Vesco et al. (2012) educated the providers and other staff on the

importance of postpartum screening, and provided them with handouts for patients. Along with education, changes to the system, such as allowing nurse care managers to place orders for screening, adding it to entry order sets for diabetic women, and providing additional reminders for patients.

Pharmacological Interventions. Mozaffari-Khosravi et al. (2012) was the only study to test a pharmacologic intervention. The intervention was a one-time high dose injection of vitamin D. The rationale for the intervention came from the role of vitamin D on glucose tolerance. Women with GDM were given 300,000units of vitamin D 3-10 days postpartum. Follow-ups were completed at 3 months after administration. Ratner et al. (2008) compared the ILS to metformin and a placebo group. No information was provided in the study about dosage.

Breastfeeding Intervention. Ziegler et al. (2012) did not test an intervention. However, they observed for duration and partial vs. exclusive breastfeeding. They also observed for variables that may affect breastfeeding behavior.

Findings

Lifestyle Interventions. In the studies that provided lifestyle modifications, common outcomes measured were weight, BMI, waist circumference, physical activity, dietary changes, cholesterol levels, fasting glucose, and OGTT. Participants receiving a lifestyle intervention showed better outcomes. However results were either not significant when compared to the control group, measured early in the postpartum period, or decreased in significance over time. This meant that the lifestyle intervention was successful initially, but women were unable to maintain results in long-term studies.

Dietary Interventions. In the two studies that provided dietary interventions, Shyam et al. (2013) had significant successful results using a low glycemic index diet, however the study

was short term. Women in this study had improvements in body weight, BMI, and waist circumference. These women also significantly increased protein and fiber intake, and decreased carbohydrate intake. Fehler et al. (2007) had significant results in diet changes initially. Women increased protein and fiber intake. However, results were not sustained long-term, and participants in this study did not have significant changes in weight or physical activity.

Screening Interventions. In the 3 studies that looked to improve screening rates, all 3 were able to increase the number of completed screenings. Capula et al. (2013) and Stasenko et al. (2011) educated patients had a larger increase in completed screening from baseline. However, these studies had lower baseline rates of completion compared to Vesco et al. (2012). Stasenko et al. (2011) also had a decrease in completion rates in the subgroup of African Americans, while other minorities showed significant increases. Capula et al. (2013) showed that factors such as age, education, parity, and treatment type during pregnancy affected completion rates. Stasenko et al. (2011) also found that adverse neonatal outcomes such as prematurity inversely affected screening completion. Vesco et al. (2012) had the highest rate of completion (71.5%) after providing subjects with additional reminders, but their baseline rate of completion for screening was higher than the other 2 studies. These studies had success bringing women in during the postpartum period for close monitoring of glucose levels, but women with GDM will need to be monitored throughout their lifetime.

Pharmacological Interventions. The vitamin D tested by Mozaffari-Khosravi et al. (2012) had no effect on fasting glucose, OGTT, or HbA1C. However, there were significant differences in the homeostatic model assessment – insulin resistance (HOMA-IR) and quantitative insulin sensitivity check index (QUICKI) compared to the control after three months. Since vitamin D had a limited affect other interventions should be considered for

women with GDM. In the study by Ratner et al. (2008), metformin was found to have increased efficacy in women with GDM when compared to women without GDM, but more research utilizing Metformin in women with GDM is needed.

Breastfeeding Intervention. In the study by Ziegler et al. (2012), breastfeeding duration was found to affect postpartum diabetes risk. However, women with higher risk, such as overweight and insulin treatment during pregnancy had shorter durations of breastfeeding. Ferrara et al. (2011) had some success, but not significant, at increasing the number of women who continued to breastfeed to at least 7 months postpartum. These studies show that breastfeeding could and should be incorporated into a T2DM prevention strategy for women with GDM.

Conclusions

This study examined available research on prevention and screening strategies for T2DM in women with GDM. The small number of eligible studies suggests that this is a new area of focus in diabetes research, and strategies for this high-risk group have not been systematically examined.

Based on the 11 studies reviewed, there is potential to delay the onset of T2DM in women with GDM. Five studies (Cao et al., 2012; Ferrara et al., 2011; Ratner et al., 2008; Shek et al., 2014; Shyam et al., 2013) were able to reduce participants' modifiable risk factors for T2DM. However due to study designs, the effectiveness of interventions were only evaluated for a short durations after implementation. In addition, not all of the outcomes examined in these studies showed significant changes, or the initial results were not maintained through the conclusion of the study. Due to the continued risk of T2DM over the lifespan, interventions that can create sustainable results are necessary for prevention.

In studies, such as Ratner et al. (2008) where participants were provided ongoing support, women with GDM were less successful long-term compared to women without GDM. It may be implied from this that there are additional factors, such as barriers or risk factors that are not being addressed. Research to examine potential barriers and risk perception in women with GDM may help develop new interventions that can remain successful over their lifetime.

Other shortcomings found in this review include small sample sizes, test populations that are not representative of those in the U.S., and study designs other than randomized-control trials. Future research should focus on increasing sample sizes, the number of studies performed in the U.S., and utilization of randomized-control trials. In addition, future studies that do not evaluate breastfeeding need to control for this variable in their sample population based on the findings from Ziegler et al. (2012).

Based on the current available data, suggestions for clinical practice cannot be made. The small amount of research and limited success does not provide the necessary evidence to make changes in practice. Studies that can present conclusive evidence in prevention strategies for women with GDM are required.

Figure 1: Literature Search Algorithm

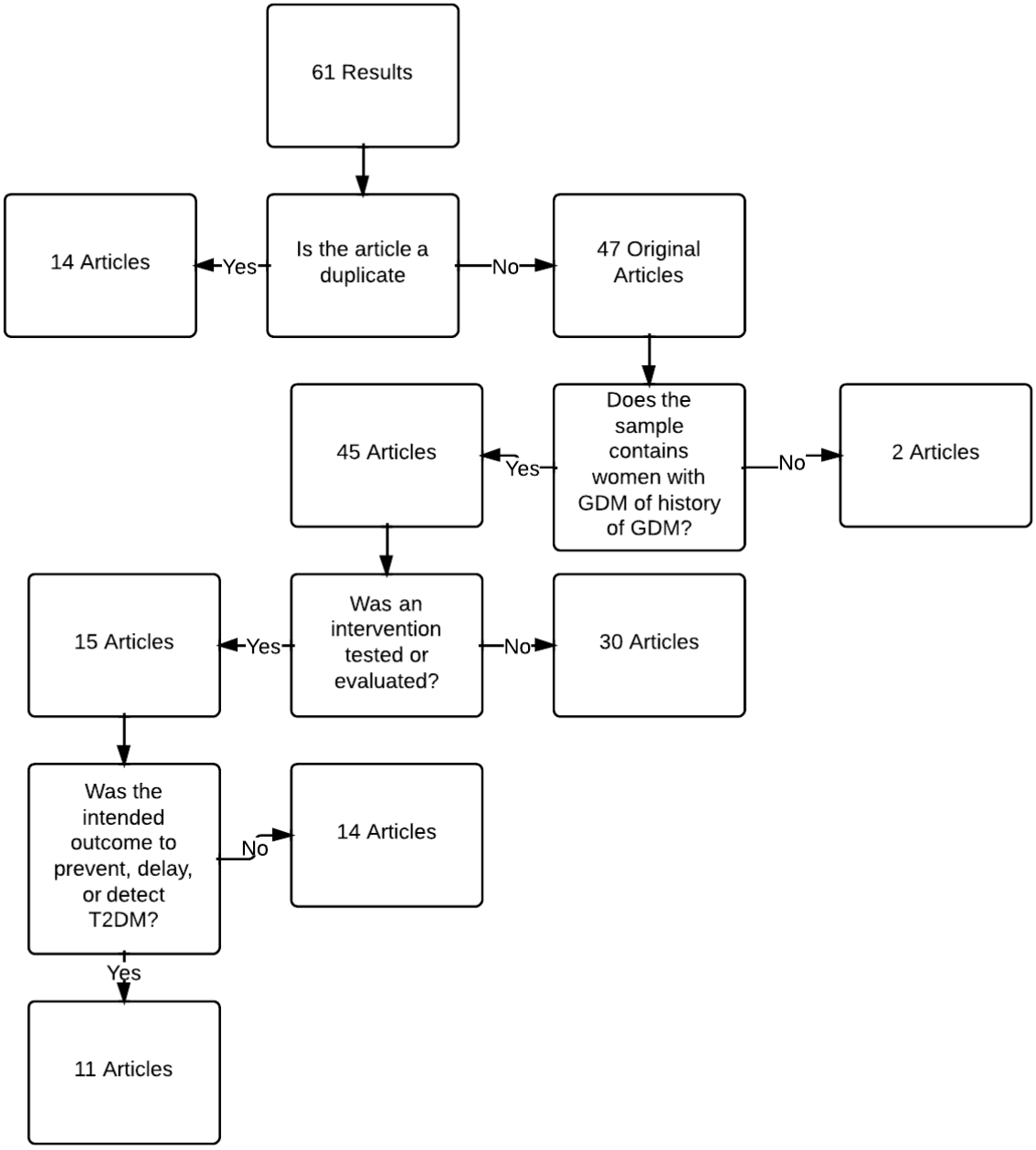

Table 1: Criteria for Diagnosis of Gestational Diabetes Mellitus

Name	Test	Criteria for GDM	
American Diabetes Association Criteria	3-hour 100-g OGTT	Fasting glucose	≥5.3 mmol/L (95 mg/dL)
		1-hour	≥10.0 mmol/L (180 mg/dL)
		2-hour	≥8.6 mmol/L (155 mg/dL)
		3-hour	≥7.8 mmol/L (140mg/dL)
Canadian Diabetes Association Clinical Practice Guidelines	2-hour 75-g OGTT	Fasting glucose	≥5.3 mmol/L (95 mg/dL)
		1 – hour	≥10.6 mmol/L (191 mg/dL)
		2 – hours	≥8.9 mmol/L (160 mg/dL)
Carpenter and Coustan criteria	3-hour 100-g OGTT	Fasting glucose	>5.3 mmol/L (95 mg/dL)
		1-hour	>10.0 mmol/L (180 mg/dL)
		2- hour	>8.6 mmol/l (155 mg/dL)
		3-hour	>7.8 mmol/L (140mg/dL)
German Diabetes Association Criteria	2- hour 75-g OGTT	Fasting glucose	>5 mmol/L (90 mg/dL)
		1-hour	>10.6 mmol/L (191 mg/dL)
		2-hour	>8.9 mmol/L (160 mg/dL)
International Association of Diabetes and Pregnancy Study Groups Criteria	2- hour 75g OGTT	Fasting glucose	>5.8 mmol/l (105 mg/dl)
		2-hour	>11.1 mmol/l (200 mg/dl)
National Diabetes Data Group	3- hour 100-g OGTT	Fasting glucose	>5.8 mmol/L (105 mg/dL)
		1-hour	>10.5 mmol/L (190 mg/dL)
		2-hour	>9.1 mmol/L (165 mg/dL)
		3-hour	>8.0mmol/l (145 mg/dL)
World Health Organization	2-hour 75-g OGTT	Fasting glucose	≥ 6.1 mmol/L (110 mg/dL)
		2 – hour	≥ 7.8 mmol/l (140 mg/dL)

Table 2: Article Analysis

Title and First Author	**Aim**	**Intervention**	**Study Design**	**Findings**	**Critiques**
A Pregnancy and Postpartum Lifestyle Intervention in Women With Gestational Diabetes Mellitus Reduces Diabetes Risk Factors Ferrara, A.	Test feasibility of a prenatal /postpartum intervention in women with a history of GDM to modify diet and physical activity similar to the Diabetes Prevention Program	A diet, exercise, and breastfeeding intervention (DEBI). Two trained dietitians to delivered intervention. Also referred to lactation consultant to learn of benefits of breastfeeding, offered a breast pump, and encouraged to breastfeed exclusively for six months. A lactation consultant also met with participants postpartum. Began right after GDM diagnosis to 12 months postpartum. Intervention included in person and telephone sessions. Participants also received written materials.	Randomized-controlled trial with n =197. Intervention group n = 96. The control group received usual care, which includes printed materials educational materials that included publicly available information on GDM. Postpartum the control received two newsletters focusing on issues related to infant safety and general health. The primary outcome measure was weight (weight goal). Secondary outcomes were breastfeeding, percent of calories from fat, and physical activity.	No significant differences between the two groups' age, race/ethnicity, and gestational age. There were lower 1 hr glucose values in 100g OGTT in the intervention group, and small differences in smoking and employment status. The number of women who reached their weight goal was higher in the intervention group but not significant. The intervention appeared to be more effective in women who did not exceed the guidelines for gestational weight gain. Decrease in dietary fat intake in the intervention group was significant at 7 months. They also increased physical activity and likelihood of breastfeeding, but neither was significant.	As a feasibility study, the number of participants and length of the study was limited. A larger sample and a longer study period would provide more comprehensive data. A large percentage (~50%) of participants were Asian American and over 80% were married. This many not be representative of the U.S. as a whole. The study did conduct focus groups that showed women wanted more information regarding health risks of GDM, support for physical activity from family and social network, online connection with other GDM women, tips for exercising with an infant, information on optimal carbohydrates, and low fat recipes.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
A system-based intervention to improve postpartum diabetes screening among women with gestational diabetes Vesco, K.K.	Determine whether a process improvement program led to increased postpartum diabetes screening rated among women with GDM.	A multiple strategy intervention. The intervention included revising the nursing protocol for care of women with GDM, enhancing the electronic medical record system, educating clinical staff, and providing additional reminders to women who did not complete the test within 3 months of delivery. Changes would include allowing nurse care managers to place orders for postpartum fasting plasma glucose (pFPG), revised electronic order entry sets to include pFPG for GDM women, and secondary reminders for providers to order the pFPG and for women to complete the test (3 by phone, 1 by email, 1 by US mail). Presentations on postpartum screening were provided for staff and nurses received a half-day diabetes training program.	Pre/Post-intervention design with n= 379 . Intervention group n= 179. The post-intervention group was compared to the pre-intervention group. The pre-intervention group's usual care for postpartum screening is not described in-depth. It only states that clinicians may order pFPG or OGTT. The primary outcomes measured were clinicians orders for pFPG or OGTT screening from 1 month through 3 months postpartum, and completed screenings. The process was evaluated on the proportion of staff attending at least 1 educational meeting, and the date and type of reminders provided to patients.	No significant differences between the two groups' BMI, maternal age, parity, ethnicity, primary language, clinical visit with nutritionist during pregnancy, treatment during pregnancy for GDM, trimester of entry into prenatal care, having a postpartum visit within 3 months, practice site where visits occurred, or infant birth weight. The increase of orders written in the post-intervention group was significant rising from 77.5% to 88.8%. The number of completed screenings at 3 months rose in the post-intervention group from 53.5% to 60.3%, but was not significant. However the completion rate after the second reminder until the completion was significant rising from 59.5% to 71.5%. The number of women receiving at least one reminder saw a significant increase from 77% to 82%. The values remained significant when comparing the reminders before and after 3 months postpartum. Staff completion of at least 1 educational meeting is as follows, 72% of clinicians, 90% of nurses, and 66% of medical assistants. Mean satisfaction was 4.82 on a scale of 1 (poor) to 5 (outstanding).	Screening interventions only increase/ improve postpartum care for women who develop impaired glucose tolerance or T2DM after GDM. This intervention does not improve T2DM development outcomes. The study population had an ethnic composition similar to that of the U.S. The multilevel approach also was effective and helped increase both placement of orders and completion of screenings. This study is also not a randomized-control trial, which is considered the optimal design.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Comprehensive intensive therapy for Chinese gestational diabetes benefits both newborns and mothers Cao, X.	Identify the impact of intensive therapy on neonatal outcomes in women with GDM and determine the effects on the postpartum metabolic status of mothers (For the purpose of this review, only the postpartum outcomes of the mothers was examined)	Individualized diabetes education, dietary and exercise advise, instruction on how to self-monitor glucose levels, and monitoring by a physician at an endocrinology clinic. Intervention began prenatally and follow-ups were 1-3 years postpartum.	Randomized-control trial with n= 275. Intervention group n = 127. The control group received a standard therapeutic regimen. This included group education on the importance of diet, exercise, and self-monitoring of glucose levels. Outcome measures were 75 g OGTT, insulin levels, lipid profiles, development of diabetes or metabolic syndrome (MS), HOMA-IR and HOMA-B, and anthropometric measurements.	No significant differences between the groups' maternal age, gestational age at diagnosis, BMI, at baseline, previous poor pregnancy outcomes, family history of diabetes, or glucose levels at GDM diagnosis. No significant differences in diagnosis of diabetes, metabolic syndrome, or impaired glucose tolerance outcomes. Intervention group had significantly smaller waist circumference, higher HDL levels, and lower glucose levels at 30 minutes. No differences in body weight, BMI, blood pressure, fasting glucose, after 2-hr glucose level, total cholesterol, triglycerides, or LDL. HOMA-B and HOMA-IR were similar to control.	The study was conducted in China, where population ethnicity is not comparable to the U.S. The study was relatively short term. Significant changes to the maternal postpartum health status were limited and impact on metabolism is still uncertain.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Effects of a single post-partum injection of high dose vitamin D on glucose tolerance and insulin resistance in mothers with first time gestational diabetes mellitus Mozaffari-Khosravi, H.	Determine the effect of a single, large IM injection of vitamin D post-partum on glucose tolerance and insulin resistance in women with gestational diabetes	The intervention group received one intramuscular injection of 300,000 units of vitamin D3 3-10 days postpartum.	Randomized control with n= 45. Intervention group n = 24. The control group did not receive any vitamin D. Both groups were told to not change their normal diet. Anthropometric measurements, fasting blood samples, and 75g OGTT were taken at the start of the trial. Follow-ups were done at 12 weeks. Outcomes measured were HbA1c, serum 25-hydroxyvitamin D3, fasting insulin and blood glucose, C-peptide, HOMA-IR Beta cell function, insulin sensitivity and QUICKI at 3 months post intervention.	No significant differences were found between the groups' BMI, month of GDM diagnosis, HbA1c, or treatment during pregnancy. The majority of the significant findings were in the control. The control group had a significant decrease in QUICKI, insulin sensitivity. The control group also had significant increases in beta cell function, fasting glucose, HOMA-IR and calcium. The only significant change in the intervention group was an increase in serum 25-hydroxyvitamin D.	The small sample size and short duration limit this study's findings. Also the difference in ethnicity and healthcare may limit applicability in the U.S. Vitamin D also only appears to delay changes in insulin sensitivity. Other interventions may be more cost effective and provide stronger preventative effect.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Lifestyle modifications in the development of diabetes mellitus and metabolic syndrome in Chinese women who had gestational diabetes mellitus: a randomized interventional trial Shek, N.W.M.	Does a lifestyle intervention reduce the development of T2DM and MS among Chinese women who had GDM	Advice on diet and exercise initially provided by a dietitian, and was and reinforced in each follow-ups by a nurse trained in dietetics. The Harris- Benedict equation was used to determine optimal caloric intake for participants' ideal body weight. Women monitored over 36 months.	Randomized-control trial with n= 450. Intervention group n = 225. No treatment given to the control group. Outcome measures included development of T2DM, anthropometric measurements, urine glucose, 75 g OGTT, insulin level, and lipid profiles.	No difference in maternal pre-pregnancy body weight, body weight on delivery, BMI at recruitment, gestation at diagnosis of GDM, plasma glucose at OGTT, gestation at delivery, birth weight, or length of baby. More women in the intervention group had GDM with previous pregnancy. The intervention group had less T2DM diagnosis at the end of 36 months, but it was not statistically significant. In women over forty, the intervention group did have significantly fewer develop GDM. The only other outcomes that were significant included lower systolic blood pressure, lower BMI, lower triglyceride, and lower fat intake in the intervention group. However, triglyceride, BMI, and fat intake did not sustain significance in all visits.	The study was conducted in China, where population ethnicity is not comparable to the U.S. The study was relatively short term. Results were not sustained throughout all visits and primary outcome of T2DM development was not significant.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Long-term protective effect of lactation on the development of type 2 diabetes in women with recent gestational diabetes mellitus Ziegler, A.G.	Investigate whether breastfeeding influences short and long-term postpartum diabetes outcomes in women with a history of GDM.	No intervention implemented. This study followed women from after delivery until development of diabetes or 19 years. Initial questionnaires and interviews determined age at delivery, treatment during pregnancy, smoking behavior during pregnancy, and parity. BMI was determined from first obstetric visit. Lactation questionnaires were given out at 9 months postpartum, and would be completed again at 2 years if still breastfeeding. Islet autoantibody status was also collected.	Observational study with n=304. Women recruited from across Germany. Participants received check ups at 2 and 9 months, 2, 5, 8, 11, and 19 years. The primary outcome measure was the development of diabetes by OGTT. Participants' physicians performed the test. A secondary outcome examined was BMI and its relationship to lactation.	There was a significant association with breastfeeding and the delay of diabetes development. Duration of breastfeeding was also inversely associated with postpartum diabetes risk. However women who were at higher risk for T2DM (required insulin during pregnancy or were over weight) had shorter duration of breastfeeding. There was also a significant association to duration of breastfeeding and postpartum BMI.	The next step to strengthen the results would be to perform a randomized-control trial testing an educational intervention to increase breastfeeding in women with GDM. The duration of this study and number of subjects strengthen finding. However, the differences in the population and available healthcare may decrease applicability to the U.S. Additional information on barriers to breastfeeding and participant's knowledge on the benefits of breastfeeding would be beneficial to future studies. Also women with increased risk for T2DM were less likely to breastfeed. This relationship needs further examination.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Low glycaemic index diets improve glucose tolerance and body weight in women with previous history of gestational diabetes: a six month randomized trial Shyam, S.	Evaluate the effects of conventional dietary recommendations administered with and without additional low-glycaemic index (GI) education in the management of glucose tolerance and body weight in Asian women with previous GDM.	In addition to the conventional recommendations stated in the study design column, the intervention group received a GI education component. They were taught to substitute high GI foods with low GI options. Education focused on strategies to select low GI options for high GI rice, bread, and breakfast cereals. Subjects were advised to restrict rice intake to once per day since local varieties had high GI, and were encourage to choose lower GI replacements. Subjects were not required to memorize numerical GI values of foods. However a list that classified foods by GI was provided to aid in making choices. Subjects were also asked to include one low GI food in each meal. Subjects were followed for 6 months after the intervention.	Randomized-control trial with n= 77. Intervention n = 39. The two diets were similar in energy and macronutrient content. Individual energy requirement was calculated by multiplying basal metabolic rate (BMR) by an appropriate activity factor based on reported physical activity pattern and occupation. Harris Benedict method was used to calculate BMR. Energy prescription was determined based on BMI and breastfeeding. Those with BMI >23 and not breastfeeding were proscribed 500Kcal less. Subjects with BMI < 23 or breastfeeding an infant < 6 months of age were their energy requirement. Energy prescriptions were rounded to the nearest hundredth and capped at 1800 Kcal/day. Each subject was given and individualized dietary sheet with the recommended number of servings for each food group of each food group per each day according to their energy prescription. They were also taught meal planning based on their energy prescription and a sample menu was provided during the intervention visit. Concepts of serving size, number of servings, and food exchange groups were taught. Each group received take-home booklets (specific to group intervention) for reference. To improve retention both groups received electronic interactions (email or short messaging service) each month. The two groups fasting blood sugar, fasting insulin, 2 hr 75 g OGTT, physical activity, and dietary intake were comparable at baseline. The primary outcome measured was a 75g OGTT after 2 hours. Secondary outcomes were fasting blood sugar, fasting serum insulin, and anthropometric measures.	Changes in the fasting blood sugar were not significant in either group. The intervention group had no significant change in 2 hr OGTT. However the control group had a significant increase in the median 2 hr OGTT. The intervention group had a significant reduction at 6 months from their baseline in body weight, BMI, waist circumference, and waist-to-hip ratio. The only significant reduction in the control group was in waist circumference. In participants with dysglycemia, weight and 2 hr OGTT values decreased slight in the intervention group, while they increased slightly in the control. Women with a higher fasting insulin (2 μIU/mL or greater) had higher percentage of weight loss in the intervention group compared to the control but it was not significant. This group did have a significant reduction in 2 hr OGTT, while the control had a significant increase. The intervention group had a significant decrease in mean percentage of calories from carbohydrates, amount of carbohydrates, diet GI, and glycaemic load from baseline. The only significant change in the control was the reduction of energy from fat. The intervention group also had significant increases in energy from protein and dietary fiber. Physical activity was still comparable between the two groups after the 6 months.	As a randomized-control trial, the findings in this study have some significance. However, with the small sample size and differences in healthcare, diet, and population compared to the U.S., findings may differ if performed in the U.S. The findings do reveal important trends for women at greater risk for T2DM. The low GI diet appears to have a beneficial effect on women with dysglycemia, higher fasting insulin, and a history of GDM. Further research on this high risk subgroup and the benefits of a low GI diet should be examined.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Patient counseling increases postpartum follow-up in women with gestational diabetes mellitus Stasenko, M.	Evaluate the efficacy of an educational intervention at increasing the rates of postpartum follow-up for women with GDM.	Participants were given antepartum verbal and written counseling on the importance of postpartum follow-up. At the 37-38 week visit, women had a 5-10 minute meeting with a nurse who is a certified diabetes educator. In the meeting, they were educated about the increased risk for T2DM and were instructed to return for a glucose screening before their postpartum checkup. Any questions were answered and participants were given a 2 page handout that contained information on follow-up recommendations and instructions, instructions for blood sugar follow-ups in the future, recommendations for weight loss and exercise as T2DM prevention strategies, and University of California, San Francisco (UCSF)- based resources. Non-English speakers were provided counseling in their primary language via telephone translator or UCSF interpreter services. The study length was 6 months.	Pre/post-intervention design with n=805. The intervention group was n= 245. The pre-intervention group was given a laboratory requisition to obtain glucose testing (fasting or OGTT) before 6 weeks postpartum at discharge. If not completed by then, they would receive another slip and be encouraged to obtain testing as quickly as possible. The primary outcome examined was whether the patients obtained postpartum glucose testing within 6 months postpartum via medical records.	Potential confounders between the groups, such as maternal ethnicity, age, GDM subtype, and preterm birth were controlled. The increase in frequency from 33.4% in the pre-intervention group to 52.7% in the post-intervention group of postpartum glucose testing was significant. When looking at subgroups such as ethnicity, white, Asian, and Latina women had significant increases. However, African American women were the only group to decrease frequency, however the decrease was not significant. When examining for age, both groups (less than 35 and 35 and older) saw significant increases. Severity of GDM (based on treatment: diet and exercise vs. medication) was analyzed. Both groups had significant increases in postpartum glucose testing frequency. The final stratification was preterm vs. term deliveries. Both groups saw an increase, but the preterm group was not significant.	Screening interventions only increase/ improve postpartum care for women who develop impaired glucose tolerance or T2DM after GDM. This intervention does not improve T2DM development outcomes. However, women were supplied with limited information on prevention strategies for T2DM. The study population had an ethnic composition similar to that of the U.S. This study is also not a randomized-control trial, which is considered the optimal design.

Title and First Author	Aim	Intervention	Study Design	Findings	Critiques
Postpartum dietary changes in women with previous gestational diabetes mellitus Fehler, K.L.	Determine whether nutrition education upon diagnosis of GDM resulted in dietary changes and whether this change was sustained postpartum.	Carried out by registered dietitian trained in GDM as standard practice. Each participant completed a diet history with a registered dietician, and a meal plan was prescribed. They then attended a group nutrition education session, which included the application of prescribed meal plans, meal frequency, the role of carbohydrates in diabetes, the use of non-nutritive sweeteners, increasing fiber intake, decreasing fact intake, increasing milk consumption, moderate juice consumption, and appropriate weight gain. They were also informed about the role of diet and exercise modification in the prevention of T2DM.	Pre/post-intervention design with n=19. The pre-intervention was the participants' baseline nutrition based on a food record. The dietician did the instruction on how to record food and beverage intake. The outcomes measured were energy, carbohydrate, fiber, protein, fat, saturated fat, folate, calcium, vitamin D, and iron intake. The study also examined physical exercise, weight loss, fasting blood glucose, and lipids.	The only significant increase was in protein and fiber at two weeks after the intervention, but it was not sustained at 6 weeks or 6 months. Calcium decreased significantly by 6 weeks and 6 months. Milk-product consumption increased significantly at 2 weeks, but was not sustained. Vitamin D significantly decreased at 6 months. Vegetables and fruits decreased significantly by 6 weeks and remained low. Body weight had not significant changes. Changes in lab values were not significant.	This study did not provide strong evidence or results. The small population size weakens data and differences in Canadian healthcare may reduce applicability to the U.S. Also the intervention did not appear to have significant success and the small improvements to the participants diet's were not sustained long-term.

Title and First Authors	Aim	Intervention	Study Design	Findings	Critiques
Predictors of postpartum glucose tolerance testing in Italian women with gestation diabetes mellitus Capula, C.	Examine the rate of postpartum glucose tolerance test (ppOGTT) for Italian women with GDM, before and after counseling, and identify demographic, clinical, and/or biochemical predictors of adherence.	Verbal and written counseling was given at 35-40 weeks of pregnancy. They were informed about the increased risk of T2DM and about the risks to start a new pregnancy with glucose intolerance. They were also provided with a handout illustrating the risk of GDM, follow-up recommendations, and suggestions for a correct lifestyle, as T2DM prevention strategy.	Pre/postintervention design with n= 1159. Intervention group n= 247. The preintervention group's usual care was not described. The primary outcome was completion of postpartum screening. Other variables were analyzed as predictors for screening completion, and included previous GDM diagnosis, education status, treatment required for GDM, BMI, ppOGTT. polycystic ovary syndrome (PCOS), family history of T2DM, and parity.	Adjustment was made for possible confounders between the two groups. The increase in adherence in the postintervention group was significant rising from 24.1% to 62.3%. Adherence to screening was significantly higher in middle/high education women, women > 30 years old, and among multigravid women. Other predictors of adherence included previous GDM diagnosis, insulin treatment for GDM. There was only a mild association when comparing high BMI women to lean women. However, PCOS was a major predictor of screening adherence.	Screening interventions only increase/ improve postpartum care for women who develop impaired glucose tolerance or T2DM after GDM. This intervention does not improve T2DM development outcomes. However, the handout to participants in the intervention group did contain content on prevention strategies for T2DM. This study also was not conducted in the U.S. and the population appeared to be homogeneous in ethnicity. Factors such as healthcare funding/availability may affect intervention effectiveness in the U.S. This study is also not a randomized-control trial, which is considered the optimal design.

Title and First Author	**Aim**	**Intervention**	**Study Design**	**Findings**	**Critiques**
Prevention of diabetes in women with a history of gestational diabetes: Effects of metformin and lifestyle intervention Ratner, R.E.	The Diabetes Prevention Program sought to identify individuals with impaired glucose tolerance and intervene in an effort to prevent or delay their progression to diabetes. This study examined women in DPP with and without GDM.	There were two intervention groups. One received metformin and the other an intensive lifestyle intervention (ILS).	Randomized control trial with n= 3234 (GDM n=350). Within the group with GDM, the lifestyle intervention n = 117 and metformin n = 111. The placebo group received represented uninterrupted progression of glucose tolerance. Women with GDM were significantly younger than parous women without GDM. Measured outcomes were weight and development of T2DM.	No significant differences between groups' parity, BMI, fasting glucose, 2 hr glucose level, HbA1C, insulin sensitivity, and insulin secretion. Lipids were similar after adjusting for age, and systolic blood pressure was lower in the GDM group. In women without GDM, ILS created the most significant change in weight. Weight loss in the ILS group with a history of GDM was less significant. Weight loss in the two metformin groups were comparable. Women with GDM were more likely to develop T2DM in the placebo group. However, the reduction of incidence in th metformin group was comparable to the ILS in women with GDM.	The study was performed in the U.S. with a ethnic distribution representative of the population. The study had a relatively short duration for testing the intervention. Also outcomes such as weight loss, were not sustained throughout the study with women regaining much of the weight.

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